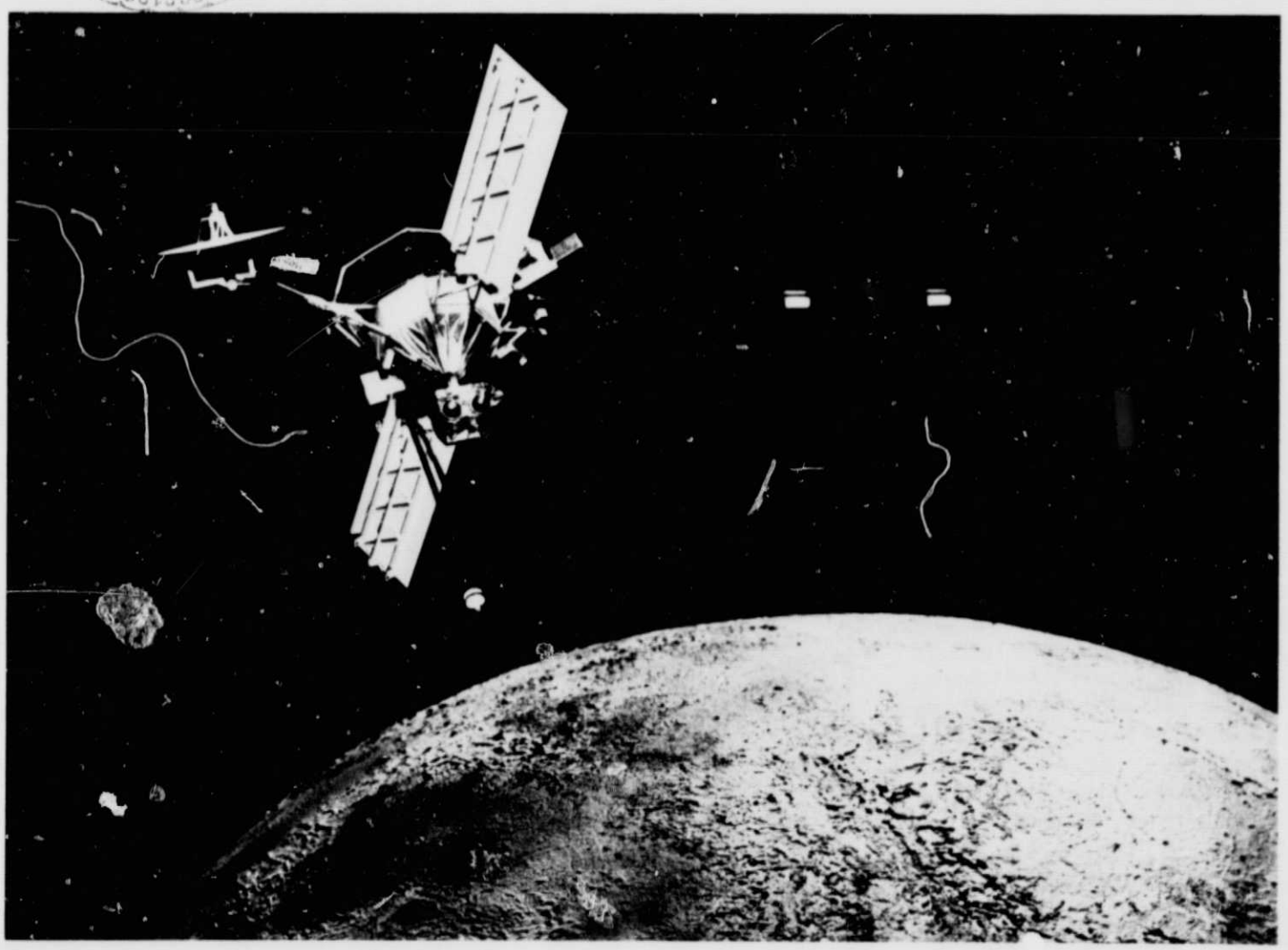
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

THE NOW FRONTIER

LINKING EARTH AND PLANETS

Venus and Mercury Encounters



JET PROPULSION LABORATORY
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ENCOUNTERING THE PLANETS

At 8.57 a.m. PST on February 5, 1974, Mariner 10 will speed past Venus only 3000 miles above the brilliant cloud tops and six minutes later disappear behind Venus. Communication with the spacecraft will then be lost for 21 minutes until Mariner emerges on the other side of the planet.

For several weeks around that date, teams of spacecraft controllers, engineers, analysts, and scientists will be running a 24-hour-a-day, three-shift operation, inspecting engineering and scientific information pouring in from the spacecraft and commanding and controlling its actions. The solar panels are tilted at increasing angles from the Sun to protect them from the greater intensity of the sunlight, and the necessary corrections are made in the trajectory.

Mission Operations System activities are centered in the Mission Control and Computing Center at the Jet Propulsion Laboratory and make use of a widespread ground data system consisting of facilities spread around the world as a part of the tracking and data system network.

Information from the spacecraft is presented to flight controllers as quickly as it is received and processed by the computers; this is almost as the events happen. The only real delay is the time—several minutes—taken for the radio waves to travel from Venus and Mercury to Earth. Television pictures of the planets are displayed on monitors similar to home television sets so that the scientists can quickly see the quality of the information coming from the spacecraft.

Computers back up the men and women at the Mission Control and Computing Center. Many computer programs are available for quick instructions to the spacecraft. For example, suppose a scientist sees something interesting on a picture returned from Mercury, an unusual crater or a volcanic cinder cone or a sinuous valley, he can call for a computer program that will generate instructions to the spacecraft camera pointing system to photograph this area again despite the rapid movement of the spacecraft and the rotation of the planet.

About 120 persons are involved in operating the spacecraft to ensure the success of the mission by keeping the spacecraft performing as it should and directing it to make the experiments required by the project scientists.

The men and women of the project have to be on the alert every second of the encounter, ready to issue correcting commands to right any problems that might arise in the spacecraft and around the worldwide data gathering net. Communications are maintained with the spacecraft at all times, 24 hours each day. As the spacecraft sets over the tracking station at Goldstone in California's Mojave Desert, it is rising for the station at Canberra, Australia. And as it sets at that station it comes into view at the next station, near Madrid, Spain. Then it is handed back to Goldstone. Antennas the size of football fields gather the incoming signals and pass the information to the control center at the Jet Propulsion Laboratory in Pasadena, California.

ENCOUNTER SEQUENCES

The first encounter is with a comet, but this is not a close encounter, since Comet Kohoutek has swung around the Sun away from Mariner. Nevertheless Mariner has the opportunity of inspecting the comet from space, photographing its head and probing it with the ultraviolet instrument. And because Mariner 10 looks at the comet at a different angle from observers on Earth, photographs can be obtained simultaneously from Earth and Mariner that provide two views of the comet, a stereo pair. These two photographs, when looked at together—one with the right eye and the other with the left in a special viewer—will let scientists see an unprecedented three-dimensional view of the comet.

Comet Kohoutek will be observed from Mariner during the period January 17 through 25, 1974. The ultraviolet airglow instrument of Mariner 10 inspects the coma (the hazy head of the comet) and the comet's long tail about January 17. Picture mosaics of Kohoutek will be obtained on January 19, 22, and 25. Four television pictures will be taken every hour for 9 hours on each of these days.

The second encounter is with Venus (Figure 1). Mariner approaches Venus from the night side of the planet. Viewing is thus unfavorable for photographs, since the cloud tops are shrouded in darkness. Moreover, since the spacecraft is in an attitude to screen its instruments from the intense radiation from the Sun, its sunshade obstructs a view of Venus. The cameras on the spacecraft do not get a glimpse of Venus until about 28 minutes before closest approach to the planet (Table 1). This opportunity may be taken to obtain photographs of the pointed ends of the crescent shape seen from Mariner, the cusps of Venus. These ends are important because the atmosphere causes them to be illuminated into the dark hemisphere, and from the observations scientists can obtain more information about the composition and structure of the Venusian atmosphere.

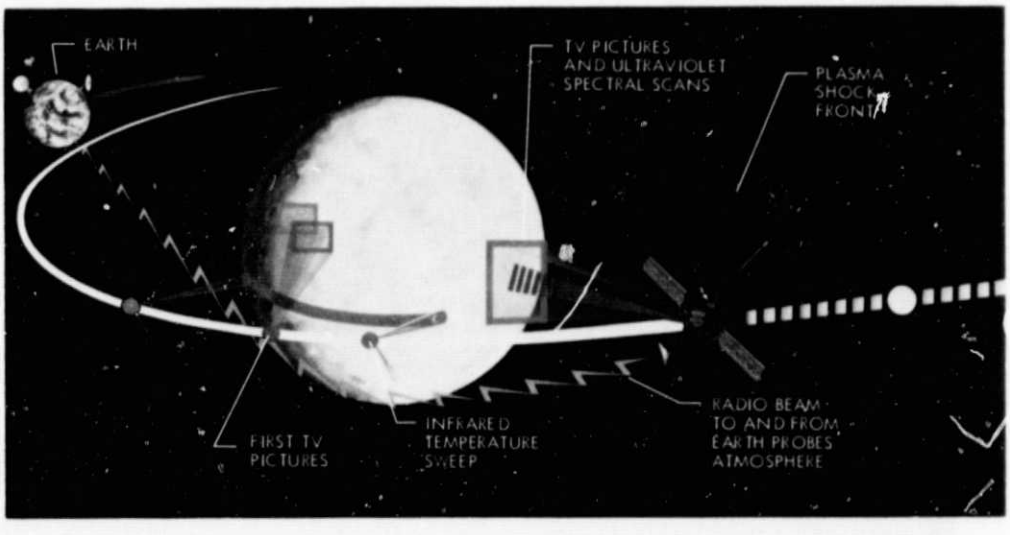

Figure 1. An artist's conception of the Mariner 10 encounter with Venus. The antennas on the Earth, of course, are not drawn to scale.

Cover: An artist's conception of Mariner 10 as it approaches the planet Mercury.

Table 1. Venus Picture Sequences

Date and time (PST)	Sequence
Feb. 5, 8.28 to 8.58 a.m.	Limb, cusps, and terminator scans
9.02 and 9.46 a.m.	Point directly beneath the Sun on the limb
10.13 a.m.	163 photo strips of Venus
12.18 p.m.	238 ultraviolet for mosaics
2.12 p.m. to 4.51 a.m., Feb. 6	1207 photos for various mosaics
Feb. 6, 9.35 a.m. through Feb. 22, 10.30 a.m.	408 pictures, one each hour

The infrared radiometer can also be used during the approach to sweep across the darkened planet and measure the temperatures of the clouds on the night side of Venus. Also, the magnetic field and particles instruments will observe the "tail" of Venus and the interaction of the planet and its electrically charged upper atmosphere (ionosphere) with the solar wind. The ultraviolet instrument will check on the auroras on the night side of Venus. These have been detected by earlier spacecraft and may be responsible for the ashen light of darkened Venus as seen by astronomers from Earth.

At the closest approach of Mariner to within 3100 miles of the cloud tops, the sunlit side of the planet has become visible and the cameras are busily photographing the brilliant cloud tops. Filters are changed to inspect the clouds in light of different colors and different planes of vibration (polarization). Some of the pictures are along the terminator line, the boundary between night and day on the planet. Because the Sun shines at a very low angle along the terminator it will reveal structural details of the clouds if they are present, just as an automobile's headlamps will show up small detail in the road surface to a pedestrian standing some way in front of the automobile and looking down at the road.

A few minutes after closest approach to Venus, Mariner sees the nearly fully illuminated disc of Venus. Series of pictures are taken in ultraviolet and polarized visible light of several colors to obtain information about the size of particles in the clouds, composition of the clouds, pressures in the atmosphere, and small- and large-scale cloud structure. Scientists hope to determine whether the clouds are hazy, foglike sheets or possess turbulent billowing tops like Earth's cumulus clouds. The cameras also photograph the limb edge of the planet to look at the cloud tops as they appear silhouetted against the dark background of space.

As Mariner flies around the daylight hemisphere of Venus it becomes hidden from Earth on the far side of the planet. Communications are temporarily interrupted. But Mariner 10 continues with all its scientific missions, storing the information, including photographs, in its memory. Then when it emerges again from behind the planet and radio waves again can get back to Earth, the information is transmitted.

As well as taking many photographs of Venus, Mariner 10 scans the clouds in ultraviolet and infrared for clues as to their composition.

But quickly Mariner flies on, its rendezvous with Venus over. As it heads back towards interplanetary space its instruments look at the solar wind and magnetic fields and particularly the effects of the bow shock where the planet plows into the environment of space like a supersonic airplane shocking the the Earth's atmosphere.

And for several days (17) after encounter, planet photography continues, the cameras looking back on the gradually diminishing disc of the planet. This 2-week series of pictures is very important. Scientists have observed rapid rotations of ultraviolet markings on Venus and major up-and-down pulsations of the atmosphere. So as Mariner recedes from Venus, emphasis is placed on time-lapse photographs of ultraviolet and any visible light markings to measure their period of rotation about the planet, which is believed to be about 4 days from Earth-based observations.

This task over, Mariner reverts to observations of interplanetary space until it begins to approach Mercury towards the end of March 1974 (Figure 2).

About 4 weeks elapse from the last pictures of Venus to the first pictures of Mercury. Mariner 10's prime target is Mercury, since other spacecraft have flown to Venus but none previously have gone to Mercury. The sequences of pictures of Mercury are the most important part of the mission, and as many pictures as possible will be taken (Table 2). The sequence is divided into five distinct parts: incoming far encounter, incoming near encounter, encounter, outgoing near encounter, and outgoing far encounter.

Mariner 10 approaches Mercury almost on a tangent to the planet's orbit near its furthest point from the Sun (aphelion). Each day in the final week before Mercury encounter, Mariner sends back to Earth sequences of pictures taken through several different color filters. Project scientists will inspect these to search for features of interest which can later be photographed in more detail as the encounter proceeds. Since no one has seen any real detail on Mercury from Earth, this pre-encounter series of photographs is awaited expectantly. As with most earlier planetary explorations, the photographs will probably be filled with many surprises.

Man's concepts of Mars were completely revised as a result of close looks by earlier spacecraft. And Mars shows quite extensive detail when observed by telescope from Earth. By contrast, Mercury shows little if any detail when seen through an Earth-based telescope, so it has remained very much a planet of mystery.

As Mariner bears down on Mercury, the ultraviolet instruments will search for evidence of an atmosphere and the infrared in-

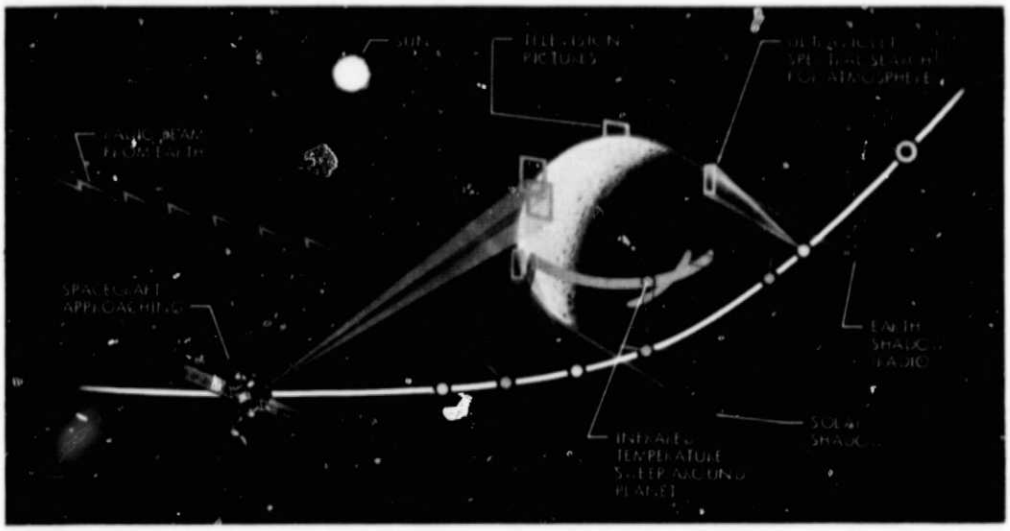

Figure 2. An artist's conception of the Mariner 10 encounter with Mercury.

strument will be checking on the temperature of the planet.

Just before encounter, the cameras will be programmed to sweep space around Mercury to see whether the planet possesses any small satellites that would be invisible from Earth.

On the day of closest approach, March 29, 1974, detailed photographic surveys are made of the surface, particularly the boundary between light and darkness where detail will be thrown into sharp relief by the low angle of sunlight shining on the planet's surface. Objects only 350 feet across are expected to be revealed on these pictures. Rapidly the illuminated shape of Mercury changes from a half-moon to a crescent as the spacecraft hurtles towards close approach. About 12.00 noon PST on March 29, Mariner flies within 600 miles of the barren surface and then starts away from the planet. But this close approach is made over the night hemisphere of the planet and the surface cannot be photographed. There are opportunities to observe and photograph the pointed ends of the crescent of Mercury, as with Venus, at the beginning and end of the night side pass. These may be inspected to check for atmosphere and for surface irregularities. Then, as Mariner moves away from the planet and over towards the daytime hemisphere, the picture taking will start again. It will continue until the image of Mercury no longer reveals any detail.

As with the Venus flyby, instruments on the spacecraft will check the interaction of the planet with the solar wind and the interplanetary medium.

Table 2. Mercury Near-Encounter Picture Sequences

Date and time (PST)	Sequence
Satellite search, March 23, 5.00 to 8.30 a.m.	45 pictures
March 27, 3.30 to 6.30 a.m.	45 pictures
Near encounter, March 28, 8.24 p.m. to 8.30 a.m. (March 29)	162 pictures (9 mosaics)
Encounter, March 29, 8.30 to 11.24 a.m.	225 pictures
11.24 to 11.37 a.m.	18 pictures
12.10 to 12.22 p.m.	17 pictures
12.22 to 4.20 p.m.	329 pictures
5.30 p.m. to 3.30 a.m. (March 30)	144 pictures

In the following months, project scientists and engineers inspect the wealth of information returned from Mercury and confer on a plan for a second encounter with this innermost planet of the solar system.

And during this period, too, while Mariner inspects the interplanetary medium, it will also look around with its cameras to see whether there are any small planets within the orbit of Mercury.

There are plans for more than 7500 pictures of Venus and Mercury during the encounters. These will provide the first photographic survey of both planets and present information impossible to obtain from Earth. Many of the pictures will be made available to national television and the newspapers within hours after being received, pictures that generations of astronomers would have given almost anything to be able to see. Thus Mariner 10 will complete much of the jigsaw puzzle of the terrestrial-type planets of the solar system and allow better understanding of how these planets were formed and evolved to their present states.

STUDENT INVOLVEMENT

Student Project One

Take the various events listed in the tables in this leaflet and make a combined listing of the sequential happening when Mariner 10 makes its encounters with its interplanetary targets. List the date, time, what happens, and leave a column for your remarks about each event. Remember that the times given here are for Pacific Standard Time (PST). (This could be an individual or a class project.)

Classroom Project

Study the results of the Mercury encounter. Discuss any unknowns that have still not been clarified by the first flyby. With the knowledge that sufficient propellant exists to make another flyby, make a plan for this next flyby: whether it should fly on the day side or the night side, what it should photograph, and why. Then later, when the next leaflet of this series is issued, check to see whether your mission plan agrees with that selected by the project scientists and compare your reasons with theirs.

READING LIST

Watch TV newscasts and special programs.
Listen to radio newscasts.
Read your local newspaper or national news-magazines.

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